



Algorithm Theoretical Basis Document (ATBD)
for the
Conical-Scanning Microwave Imager/Sounder (CMIS)
Environmental Data Records (EDRs)

Volume 15: Test and Validation

Covering: All EDRs

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RELATED CMIS DOCUMENTATION

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Title	Version	Authorship	Date
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Boeing Satellite Systems Documents

Title		Covering
ATBD for the CMIS TDR/SDR Algorithms		
ATBD for the CMIS EDRs	Volume 1: Overview	Part 1: Integration Part 2: Spatial Data Processing <ul style="list-style-type: none"> Footprint Matching and Interpolation Gridding Imagery EDR
	Volume 2: Core Physical Inversion Module	
	Volume 3: Water Vapor EDRs	Atmospheric Vertical Moisture Profile EDR Precipitable Water EDR
	Volume 4: Atmospheric Vertical Temperature Profile EDR	
	Volume 5: Precipitation Type and Rate EDR	
	Volume 6: Pressure Profile EDR	
	Volume 7: Cloud EDRs	Part 1: Cloud Ice Water Path EDR Part 2: Cloud Liquid Water EDR Part 3: Cloud Base Height EDR
	Volume 8: Total Water Content EDR	
	Volume 9: Soil Moisture EDR	
	Volume 10: Snow Cover/Depth EDR	
	Volume 11: Vegetation/Surface Type EDR	
	Volume 12: Ice EDRs	Sea Ice Age and Sea Ice Edge Motion EDR Fresh Water Ice EDR
	Volume 13: Surface Temperature EDRs	Land Surface Temperature EDR Ice Surface Temperature EDR
	Volume 14: Ocean EDR Algorithm Suite	Sea Surface Temperature EDR Sea Surface Wind Speed/Direction EDR Surface Wind Stress EDR

Title		Covering
	Volume 15: Test and Validation	All EDRs

Bold = this document

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1 Introduction

1.1 Objective

This document describes test and validation methods for the CMIS EDR algorithms. It complements material presented in the other *ATBD for the CMIS EDRs* volumes (listed above under Related CMIS Documentation) covering each EDR individually. General test and validation philosophy, methods, and limitations are presented with descriptions of data involved in the procedure and its availability. We list currently available data sources and identify additional data sources necessary either to validate or improve algorithm performance. We describe the role of simulation in algorithm testing including model development and interaction between simulations and more limited real-data tests. Procedures are presented for end-to-end validation processing.

1.2 Scope

This volume covers test and validation plans and results to be completed prior to CMIS hardware delivery. It does not cover so-called calibration/validation (CAL/VAL) efforts to be performed post-launch but provides significant preliminary ground-work and may be considered the basis for an outline of these efforts. Detailed descriptions of the individual EDR algorithm theoretical bases, mathematics, and performance predictions are given in the other volumes of this ATBD. This document is a work-in-progress and is intended to be updated as new validation tests are formulated, results are produced, and analyses are completed.

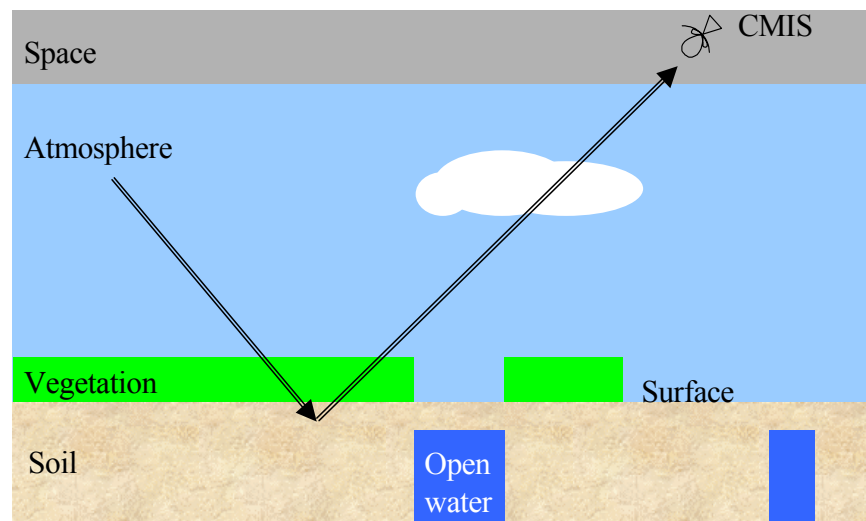
2 Overview

2.1 Test methods

The CMIS EDR algorithm test and validation methodology integrates traditional simulation and analysis with tests using "real" data from analogous sensors. Four primary approaches are used to different degrees for each EDR:

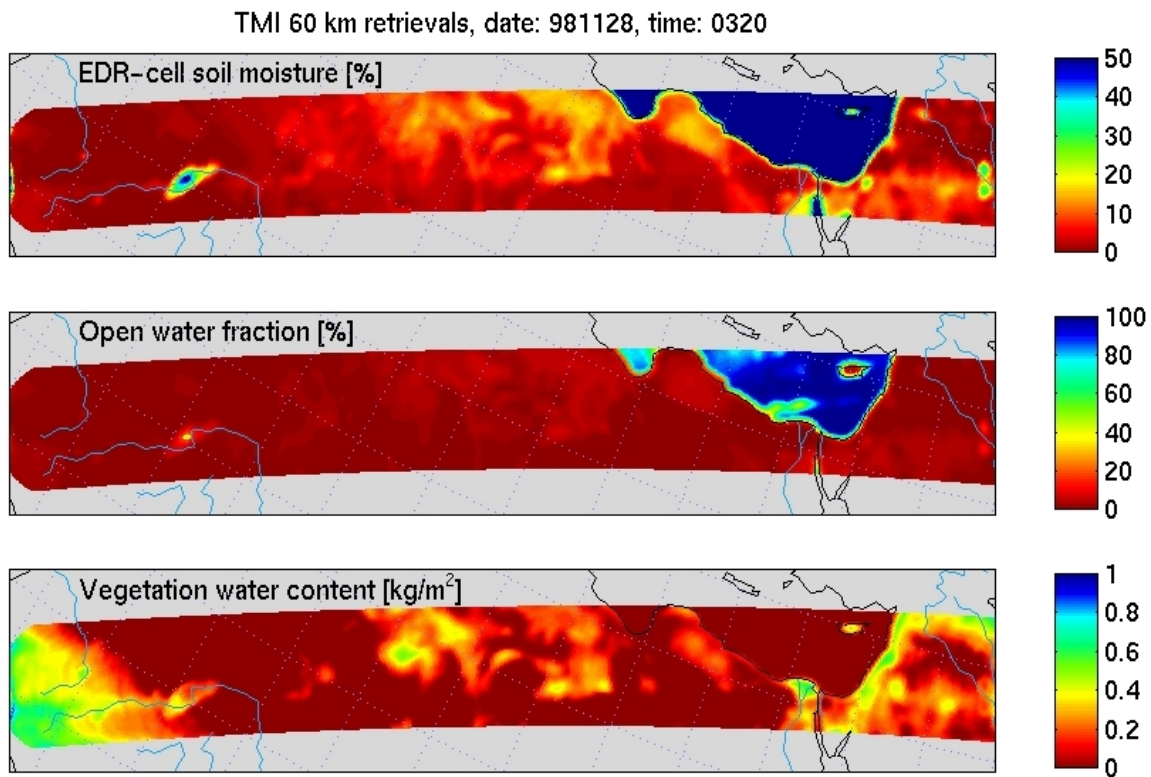
1. *Simulation* — Scene data "truth" covering all environmental factors contributing to the measured brightness temperature signal are developed from observations (e.g., radiosondes), randomized selection from a given parameter distribution, or a combination of the two. Radiative transfer models are applied to the simulated environment to generate a simulated sensor response (e.g., brightness temperatures), included sensor errors. The algorithm is executed using simulated sensor measurement inputs and the algorithm products are compared to the scene data "truth." The advantage of the method is that the scene truth can be known to arbitrary precision and retrieval performance can be easily stratified according to any of the simulated parameters (whether measured or not), the degree of sensor noise or variability in a particular environmental parameter, or the available channel set. The method is limited by the degree to which assumptions must be made about environmental conditions and the accuracy of radiative transfer methods.

Figure 2-1: Schematic showing how simulations represent natural phenomenon



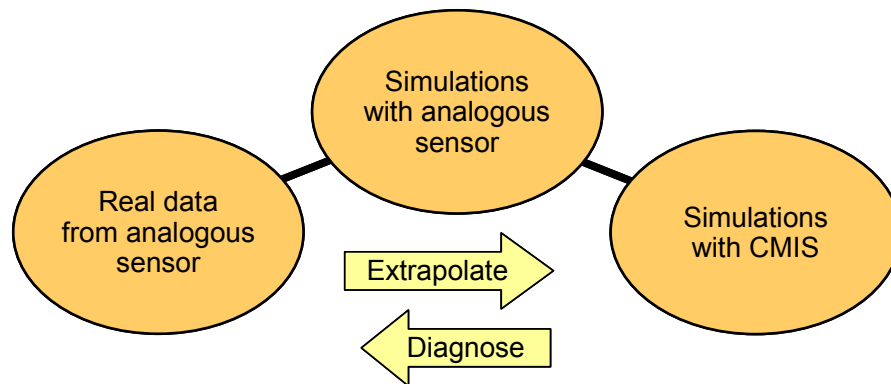
2. *Retrievals with analogous data* — The algorithm is executed using measurements from a passive microwave sensor with characteristics similar to CMIS. The algorithm products are either compared to ground truth measurement where they are available or analyzed for self-consistency, consistency with other scene attributes, robustness, and other factors. Analogous data tests are limited by the degree of similarity between the selected sensor and CMIS and the quality and availability of the ground truth. The advantage is that the algorithms can be tested end-to-end with data that is truly representative of natural environmental conditions and variability.

Figure 2-2: Soil moisture algorithm test using CMIS-analogous data from TMI



3. *Three-way trials* — Integrates real-data test from analogous sensor with CMIS simulations using simulations of the analogous sensor performance. Simulation of the analogous sensor provides the link between the real-data tests and the CMIS simulations and this link helps validate the algorithm and simulation methodology which in turn enhances the reliability of CMIS performance predictions. The method provides a bridge for extrapolating real-data performance to the CMIS configuration and the wider range of test cases and environmental stratification available from simulations. Conversely, three-way trials facilitate diagnosis of real-data test behaviors.

Figure 2-3: Schematic of algorithm testing using the three-way trial method



4. *Scene consistency evaluation* — The algorithm is executed from either analogous sensor data or simulated data that includes some degree of spatial structure—e.g, a coastline, cloud edge, or other abrupt feature. The retrieval products are analyzed for artifacts that may have been introduced by the presence of the feature—for example, water vapor

retrievals should not change abruptly across a coastline (see [EN #61](#) response). Scene evaluation is useful for identifying possible sources of retrieval contamination and for validating retrieval robustness under diverse conditions.

2.2 Error sources

The objective of the algorithm test and validation process is to account for all sources that might contribute to CMIS EDR measurement errors such that reliable measurement error predictions can be made. By breaking down the measurement error by source, the impact of each error source can be assessed relative to how well the error source itself can be characterized. For example, if simulations show that an error source has negligible impact on the measurement, then rigorous methods do not need to be developed to further evaluate that source. Table 2-1 lists the types of error sources that are accounted for in simulations and algorithm error budgets.

Table 2-1: Types of error sources accounted for in simulations and error budgets

Error Term	Comments
Radiometric noise	NEDT computed on-the-fly Includes calibration noise
Residual calibration and systematic radiative transfer model errors	Incorporates calibration accuracy and interchannel accuracy and spectroscopic biases
Spectroscopic error	Random component
Polarization/alignment uncertainty	Key for sea EDRs
Sub-field-of-view effects	Includes beamfilling, partial cloud cover, indirect path radiation
Channel spatial coregistration errors	Estimated by analysis/simulation
Channel temporal coregistration errors	Analysis indicates these are negligible
External data errors	
Geophysical effect uncertainty	Faraday rotation and Zeeman splitting
Environmental uncertainties	Uncertainties in unretrieved parameters of soil, vegetation, atmosphere, ionosphere
Interpolation error	Remapping, vertical registration
Cell mismatch error	Difference between antenna/algorithm response pattern and square verification cell

2.3 Stratification

The EDR algorithms must be tested over a broad range of environmental conditions to validate both global applicability and tolerance for any stressing conditions which may be important for CMIS users. Test results are stratified to show the relationship between algorithm performance and changes in environmental conditions. Table 2-2 addresses binning of error statistics within the measurement ranges of the EDRs. For each EDR product, we list the number of bins into which the measurement range should be divided for reporting performance statistics.

Table 2-2: Binning of error statistics within EDR measurement ranges

EDR Product	Number of Bins
Temperature	1
Moisture *	8
Pressure	1
TPW	6
CLW	6
IWP *	6
TWC	5
Cloud base height	3
Precipitation *	6
SST	8
Wind direction	8
Wind speed	8
Wind stress	5
Soil moisture	5
LST	3
IST	3
Snow cover	5
Vegetation/surface type	8 types
Sea ice age	FY, MY
Sea ice concentration	5
Sea ice edge	N/A
Sea ice edge motion	5
Fresh water ice conc.	5
Fresh water ice edge	N/A

*divided in increments of logarithm of the EDR

Table 2-3 addresses other factors that may affect EDR algorithm performance, apart from the value of the EDR itself. These factors include environmental variables and variables related to view geometry. For each EDR, there is a list of variables that may significantly affect performance and for each variable there is a list of values at which performance should be evaluated. In simulations, the variables can take on the exact values listed. In evaluations of real data, the data can be binned about these values. For each variable, one or more values are highlighted. The highlighted values are the default values to use while the other variables are changed. The use of default values is required because it is not possible to consider every possible combination of variables. However, it may be worthwhile to consider some combinations for some variables, where there is reason to suspect that performance of a particular EDR may depend on an interaction between variables.

Table 2-3: Factors other than the value of the EDR itself that may affect EDR performance

	Scan Pos	Lat/Seas	Vapor	CLW	Cld Frac	IWP	Ice Dme	Precip rate	Precip type	Mag Field		
Temperature	X	X	X	X		X	X	X		X		
Moisture	X	X		X	X	X	X	X				
Pressure	X		X					X				
TPW	X	X	X	X		X	X	X				
CLW	X	X	X		X	X	X	X				
IWP	X	X	X	X	X		X					
TWC	X	X	X	X	X	X	X	X				
Cloud base	X	X	X	X	X	X	X	X				
Precip	X	X	X	X	X				X			
SST	X		X	X				X				
Wind direction	X		X	X				X				
Wind speed	X		X	X				X				
Wind stress	X		X	X				X				
Soil moisture	X		X	X				X				
LST	X		X	X		X	X	X				
IST	X		X	X		X	X	X				
Snow cover	X		X	X		X	X	X				
Veg./sur. type	X		X	X		X	X	X				
Sea ice	X		X	X		X	X	X				
Fresh watr ice	X		X	X		X	X	X				
	Scan Pos	Lat/Seas	Vapor	CLW	Cld Frac	IWP	Ice Dme	Precip rate	Precip type	Mag Field		
	km			kg/m2		kg/m2	micrometers	mm/h		Ascen node	Orbit frac	Scan Pos
	0	tropical	high	0	0	0	50	0	warm convec	pole long	0	-1700
	800	midlat s/f	low	0.1	0.1	0.1	100	2	cold convec rain	pole long+90	1/12	0
	1700	polar wint		0.2	0.5	2	200	5	cold convec snow		1/6	1700
				0.5	1		300	10	MCS		1/4	
				1			400		orographic rain		1/3	
			random						orographic snow		5/12	
									stratiform rain			
									stratiform snow			
									various			

Table 2-3 (continued)

	Wind speed	Wind direc	Sun glitter	Sfc type	Sfc Water frac	VWC	Veg Frac	Tsfc grad	Land Frac	RMS Alt
Temperature				X						
Moisture				X						
Pressure				X						
TPW				X						
CLW				X						
IWP				X						
TWC				X						
Cloud base				X						
Precip				X						
SST	X	X	X		X					
Wind direction	X		X		X					
Wind speed		X	X		X					
Wind stress			X		X					
Soil moisture					X	X	X			X
LST				X	X		X			X
IST					X		X	X		
Snow cover				X	X		X			X
Veg./sur. type										X
Sea ice										
Fresh watr ice										
	Wind speed	Wind direc	Sun glitter	Sfc type	Sfc Water frac	VWC	Veg Frac	Tsfc grad	Land Frac	RMS Alt
	m/s	degrees	degrees			kg/m2		K/m		m
	3	0	0	veget	0	0	0	0	0	0
	5	90	10	bare soil	0.1	0.5	0.1	5	0.1	100
	8	180	20	snow	0.5	1	0.5	10	0.5	500
	12		30	ice	0.9	1.5	0.9		0.9	
	20		180		1	2	1			
	random	random								

In selecting the numbers of bins and the numbers of values of the variables, we attempted to give a minimal number while ensuring that the primary performance trends would be well

represented. Not all levels of performance factors need to be computed, but there must be enough points on the performance curve so that interpolation or extrapolation could be used to give a sufficiently accurate estimate of performance at any intermediate value of the variable. The following list defines each factor:

- *Scan position*: The spacing and orientation of CMIS footprints varies with position across the scan. When individual footprints are averaged into composite fields of view, the averaging achieves noise reduction and the noise reduction factors vary with scan footprint spacing and orientation. The worst case (largest factors) occurs at center of scan, which is the default in our performance tests. Other algorithms that do spatial processing may depend on spacing and orientation of footprints. These include Precipitation, Sea Ice Edge Motion, Snow Cover, and algorithms that perform regridding to the local vertical, such as AVMP and AVTP.
- *Latitude/season*: The structure of the atmospheric temperature and water vapor, as a function of pressure or altitude, varies with latitude and season, as does the relationship between the surface and air temperatures. Such structure can have an impact on performance for some EDRs, particularly for atmospheric sounding EDRs.
- *Vapor*: The amount of water vapor in the atmosphere may significantly affect the transparency of the atmosphere and can thus affect performance of EDRs. Algorithms are tested with different amounts of atmospheric water vapor, usually by considering a set of test atmospheric profiles with a large range of total precipitable water values.
- *Cloud liquid water (CLW)*: The issues are similar to vapor.
- *Cloud height*: This refers to the altitude or pressure range at which the cloud water occurs. The lower frequency channels, and the EDRs that depend mostly on them, are not strongly affected by cloud water and are insensitive to cloud height.
- *Cloud fraction*: The cloud cover over a CMIS field of view may be non-uniform. This effect may be modeled by assuming that a fraction of the field of view is cloudy and the rest is clear.
- *Ice water path (IWP)*: The issues are similar to vapor.
- *Ice particle size (D_{me})*: Radiances at the higher frequencies are sensitive to the size of ice particles within clouds. EDRs that depend heavily on the high-frequency channels are tested with varying particle size.
- *Precipitation rate*: The EDR performance is not directly sensitive to the rate at which precipitation strikes the ground, but may be sensitive to the liquid and ice particles in a precipitating atmosphere. The stratifications are generally made with respect to the amounts and sizes of the particles in the atmosphere. Models can be used to convert these atmosphere properties to approximate precipitation rates, so that EDR performance can be described with respect to precipitation rate.
- *Precipitation type*: The overall cloud structure affects the skill with which the CMIS radiometric data can be related to precipitation rate. This stratification criterion is really focused on the overall cloud structure.
- *Faraday rotation uncertainty*: The uncertainty in the degree of Faraday rotation varies with latitude and status of the solar cycle. The rotation and its uncertainty are functions of the total electron content and the magnetic field and their uncertainties. EDRs that depend heavily on the polarimetric channels are tested against this uncertainty.
- *Magnetic field*: Upper atmosphere radiative transfer and performance of the AVTP EDR depend on the state of the geomagnetic field. The field varies over the globe. The relevant aspects of the field at any CMIS measurement location are the magnitude and two angles that describe its orientation with respect to the satellite view path.

- *Wind speed*: Performance for some sea EDRs may depend significantly on wind speed. Atmosphere EDRs retrieved over sea surfaces are not stratified by wind speed, but performance is computed with cases that have a range of wind speeds.
- *Wind direction*: Performance for some sea EDRs may depend significantly on wind direction.
- *Sun glitter*: The intensity of sun glitter may be modeled as a function of the angle between the view path of the satellite and the path that a specularly reflected ray of sunlight would travel. We do not plan to show performance as a function of sun glitter, but to indicate the minimum value of this angle at which we expect to make threshold.
- *Surface type*: The CMIS sensor data depend on the emissivity spectrum of the surface. A given type of surface, such as snow, tends to have certain characteristics of its emissivity spectrum. Performance may be stratified against surface type, where performance is for a single representative emissivity spectrum for each type or for a pooling of results from a range of spectra that may occur for each type. Alternatively, performance may be stratified according to certain characteristics of the emissivity spectrum itself. For snow cover and soil moisture EDRs, retrieval performance depends on surface type because of different degrees of environmental noise. Surface type EDR performance depends on surface type because the range of spectra for a given type overlaps those of other types by varying degrees.
- *Surface water fraction*: This is the fraction of the CMIS field of view composed of liquid water. This parameter may be used to represent coastal conditions along oceans, lakes, or rivers or flooding/standing water conditions.
- *Vegetation water content (VWC)* : This is a measure of the mass of water contained within vegetation per unit area. It represents the degree of soil masking by vegetation which affects soil moisture retrieval performance.
- *Vegetation fraction*: An inhomogeneous field of view is modeled as having vegetation (with a specified spectral signature) in a fraction of the field of view and bare soil in the rest.
- *Surface temperature (T_{sfc}) gradient*: Ice surface temperature retrieval depends on the vertical gradient of temperature from the surface of the ice downward.
- *Land fraction*: This is similar to surface water fraction, but applies to borders of ice over land.
- *Root-mean-square (rms) altitude*: This represents the inhomogeneity of a field of view with respect to the altitude of surface. A high value of this parameter occurs in mountainous terrain.

The factors we have listed do not include external data sources. For each external data source required by an algorithm, the EDR performance should be evaluated for at least four levels of error of the external data:

1. the nominal error value,
2. the error value that the algorithm provider states is required for threshold performance,
3. the largest error value that can be expected to occur in unusual, but not unrealistic, circumstances, and
4. absent external data.

Further performance breakdown is needed to characterize algorithm product degradation when sensor performance degrades primarily because of loss of one or more channel. We test each EDR algorithm while eliminating data from selected channels or bands of channels (e.g, all the 183 GHz channels). These tests provide performance data covering possible sensor channel

(e.g., receiver) failures, radio-frequency interference (RFI) scenarios (e.g., affecting both 6V and 6H channels simultaneously), channel-dependent environmental contamination (e.g., rainfall), spatial-sampling considerations, and sensor design trades.

2.3.1 EDR stratification rational

Temperature Profiles

The concept of binning by EDR value for performance need not be applied to the temperature profile because the measurement sensitivity is not dependent on the temperature. The dominant performance driver for temperature, and other profile EDRs, is the scale and amplitude of the vertical structure in the profile. To some degree, these effects can be dealt with by stratifying according to season/latitude. For example, errors may be relatively large near the altitude of the tropopause, which depends on latitude and season. Another indicator of the degree of difficulty in sounding profile may be obtained for instance by deriving a set of EOFs from global analysis and choosing profiles according to their principal components for the least significant eigenvectors. Upper atmosphere temperature EDR performance may be affected by the local magnitude of Doppler shifting. This factor may be accounted for by varying the scan position.

Moisture Profiles

A critical factor for moisture profiling is the vertical lapse rate of temperature. Particular attention should be paid to winter land cases where inversions are frequent, cases of cold air outbreak over coastal areas, and cases of sharp contrast between surface skin temperature and air temperature. Binning of moisture profile errors requires relatively many bins because, at each vertical level, only some of the bins will be populated. Water vapor varies greatly over altitude and season, so the number of bins must be sufficient to distinguish, for example, dry conditions from moist conditions at 300 mb near the poles or at 1000 mb near the equator.

Dependence On Surface Emissivity

Performance of sounding EDRs (temperature, moisture, pressure profiles, precipitable water, and cloud EDRs - CLW, IWP, TWC, precipitation and cloud base height) near surface depends on emissive properties of the surface as well as a priori uncertainties on estimates of these properties. Sounding EDR performance should be tested over a set of globally representative surfaces over land and sea ice to assess algorithm response to changes in surface characteristics. Robustness of an algorithm depends on the mechanism used for including *a priori* knowledge and the dependence of the solution on such *a priori* knowledge. Robustness must be assessed by simulating stressful conditions. Particularly difficult cases include regions of low vegetation and moisture content (e.g. arid and semi-arid regions, tundra) where emissivities are poorly known and instances of rapidly changing emissivities due to snow, natural/manmade events (e.g. flooding, deforestation) and changing moisture content over bare lands.

Cloud Fraction

This variable is used to represent the differing response of algorithms to stratiform and convective clouds and the beamfilling issue for precipitation retrieval.

Cloud Ice Particle Size

Cloud ice particle size is represented by the median mass diameter (D_{me}). Some EDRs will be affected by cloud ice only when the ice particles are large.

Magnetic Field

The magnetic field is relevant only to high altitude temperature sounding. The magnetic field strength is important, as is its orientation relative to the satellite view and relative to the polarization orientation/basis of the instrument. We recommend assessing this factor by considering a representative range of view conditions, relative to the longitude of the magnetic pole. The scan position must also be considered. By specifying the view conditions, rather than directly specifying the magnetic field, the performance will take account of the particular polarization implementation being used.

Sun Glitter

Sun glitter is measured by comparing the view path from the satellite to some point on the sea surface to the path that solar radiation would make upon specular reflection from that point on the sea surface. The angle between those two paths is the measure of sun glitter. If the angle is zero, the satellite is viewing directly into the path of specularly reflected solar radiation. If the angle is greater than 90 degrees, there is no solar radiation at all.

Inhomogeneity Within Cells

The surface water fraction is a means to represent the fraction of a horizontal cell that is covered by water. This factor may account for coastal effects as well as small water bodies. The vegetated cover fraction, the land fraction (for areas with part ice cover), and the rms altitude variation within a cell also address inhomogeneity.

2.4 Databases

Table 2-1 lists datasets used currently in CMIS algorithm test and validation. Reliable datasets are necessary both to validate nominal and stressing condition performance as well as enhance the capabilities of the algorithms. Further data collection will be an ongoing process occurring in parallel to test and validation efforts. Additional untapped data are available to AER through Cooperative Research and Development Agreements (CRDAs) with the Air Force Weather Agency (AFWA) and the Air Force Research Laboratory (AFRL):

- AFWA CRDA: Gives AER timely access to AFWA's global meteorological databases (all non-classified), forecasts (including cloud, mesoscale, agrimet, aviation, and space weather), satellite imagery databases, applications software, and value-added products. AFWA is an operational center supporting Air Force, Army, and national programs with global weather data, forecasts, and mission products. Production operation involves over 140,000 weather reports per day from conventional sources, as well as those from military and civilian meteorological satellites and other environmental data sources. AFWA possesses a huge archive of weather and climate data through the Air Force Combat Climatology Center (AFCCC) operating location at the National Climatic Data Center (NCDC).
- AFRL CRDA: Gives AER access to real-time satellite data from DMSP, NOAA, and GOES satellites and data processing software and hardware.

Table 2-4: Databases currently in use for CMIS test and validation

Data	Type	Application
NOAA-88, TIGR-2 RSS Radiosonde and NCEP-Orbit Dataset*	Global Profile Datasets	Retrievals of temperature and moisture profiles, Tskin, CLW, Sea EDRs etc...
Rosenkranz dataset High-latitude dataset	Rocketsonde	Retrievals of upper atmosphere temperature
CRISTA temperature profiles	Limb sounder retrievals	Retrievals of upper atmosphere temperature
ARM	RAOBs at ARM locations (Southern Great plains, North Slope of Alaska, Tropical Western Pacific)	Retrievals of temperature and moisture profiles
Eta, RAMS, and MM5 outputs, ECMWF and NCEP* analysis	Atmospheric Fields	Generating profile samples and scenes
AMSU	Global Microwave Radiance Measurements	Retrieval of temperature profiles, PW and cloud water
SSM/I, TMI, SMMR	Global Microwave Radiance Measurements	CLW, PW, Precip, Ice, Snow EDRs, Land EDRs
CEPEX (Central Equatorial Pacific Experiment)	Field Experiment	Cloud ice water content and particle size observations for ice clouds simulations
Land/Water Mask*	1/12 degree	Sea, Land and Ice EDRs
Climatology Salinity*	Monthly maps from World Ocean Atlas (Levitus, 1994)	Sea EDRs
Ionosphere Electron Content*	Haramonic Coefficients (International Reference Ionosphere, 1995)	Sea EDRs
International Geomagnetic Reference Field	Geomagnetic field vectors	Upper atmosphere radiative transfer, Sea EDRs
Shelter Temperatures	Surface Observation	Land Surface Temperature
AVHRR	Imagery	Fresh Water Ice Concentration/Edge, Sea Ice Concentration/Edge/Edge Motion
Prigent Emissivity Database	Global Monthly-Average Emissivity Database	Retrievals over land
TRMM VIRS	Vis/IR imagery	Land Surface Temperature
NWS NOHRSC 1 km Satellite Snow Cover	Real-time Analysis Map	Snow Cover
USGS Global Land Cover Characterization	Static database	Vegetation/Surface Type

* Remote Sensing Systems dataset

Table 2-5 lists upcoming missions that will provide key analogous sensor data for algorithm tests. SSMIS will be the first instrument having both sounding and window channels on a conical scan. AMSR will have the first sensor at 6 GHz since SMMR (1978-1987) and will have coordinated retrieval product validation campaigns including ground truth collection for products similar to CMIS EDRs (e.g., soil moisture, ice concentration). Windsat has channels necessary for ocean wind and SST tests. HIRDLS, while not a microwave sensor, will provide valuable data on the upper atmosphere that can then be used to improve the realism and global representativeness of the CMIS simulation environment.

Table 2-5: Key future data sources

Data Source	Description	Time Frame
SSMIS	<ul style="list-style-type: none"> Operational conically scanning microwave instrument with channel set similar to CMIS (18-183 GHz) Algorithm validation opportunity for most CMIS EDRs 	Fall 2001
AMSR	<ul style="list-style-type: none"> EOS-Aqua and ADEOS-II platforms Window channels from 7 to 90 GHz Particular application to sea, ice, soil moisture, land, and precipitation EDRs 	Fall 2001
Windsat	<ul style="list-style-type: none"> 7-37 GHz analogous channels Orbit parameters similar to CMIS Can be used for all ocean EDRs 	Early 2002
HIRDLS	<ul style="list-style-type: none"> Infrared limb sounder on EOS-CHEM platform Provides temperature profile simulation and validation data to about 80 km altitude 	Late 2002

2.5 EDR validation method summary

Table 2-6 summarizes the main methods for test and validation and the key data sources for each EDR. The individual EDR ATBD volumes present detailed test methods and results to-date.

Table 2-6: Summary of primary validation methods and data sources

EDR	Methods	Key Data Sources
AVTP	3	RAOBs (radiosonde observations), ground-based lidar, AMSU, SSMIS
Pres Pro	S	RAOBs
AVMP	3	RAOBs, ARM multi-sensor data, AMSU, SSMIS
PW	3	RAOBs, ARM multi-sensor data, AMSU, SSMIS
CLW	3	Radiometers, cloud imagery, ARM field studies AMSU, SSMIS
CIWP	S,R	Field studies, cloud imagery, MIR, SSMIS
TWC	S,R	ARM multi-sensor data, AMSU, SSMIS
CBH	S,R	Ceilometer, ARM cloud radar, SSMIS
Precip	S,R	Gauge, ground-based radar, TRMM, AMSR
LST	3	Surface obs, IR retrievals, SSMIS, AMSR
IST	3	Surface obs, IR retrievals, SSMIS, AMSR
FWI	S, R	SSM/I, AVHRR
SIA	S, R	SSM/I, NASA/NOAA Polar Pathfinder data, AVHRR
SIEM	S, R	SSM/I, AVHRR
Soil Moi	S, R	SSM/I, TRMM TMI, SSMIS, AMSR, SMMR
Snow	S, R	SSM/I, coregistered NWS NOHRSC 1 km Satellite Snow Cover data
VST	S, R	SSM/I, TMI, USGS Global Land Cover
SST	S, R	RAOBs, TMI, ADEOS-2 AMSR and PM, NCEP Global Fields
SSW-S	S, R	RAOBs, TMI, ADEOS-2 AMSR and PM, NCEP Global Fields, Windsat
SSW-D	S, R	RAOBs, ADEOS-2 AMSR and PM, NCEP Global Fields, Windsat
SWS	S, R	RAOBs, TMI, ADEOS-2 AMSR, NCEP Global Fields, Windsat
Imagery	C	

Legend: S = Simulation tests, R = Real analogous data tests, 3 = 3-way tests, C = Consistency tests